TOMORROW'S AGRICULTURE -- THE RESEARCH PERSPECTIVE

Address by Dr. Byron T. Shaw, Administrator, Agricultural Research Service, U. S. Department of Agriculture, at the Joint Meeting of the Philadelphia Society for Promoting Agriculture and the Franklin Institute, in Philadelphia, Pa., April 22, 1959.

It is a great privilege to be here tonight. I am deeply honored to be chosen as the recipient of the 1959 Agricultural Award of the Philadelphia Society for Promoting Agriculture. I am confident, however, that your distinguished Society, in making its choice, was thinking of all the research scientists in the Department of Agriculture and their many contributions to the Nation's welfare. It therefore seems to me appropriate to accept the Award on behalf of my colleagues, as well as myself. We are gratified to receive this recognition from a group so eminent in its support of agricultural science.

I appreciate also the opportunity to participate in this joint meeting of the Society and the Franklin Institute. It is always a pleasure for me to discuss agricultural research with people who have a real and continuing interest in scientific progress.

When Colonel Biddle invited me to speak tonight, he didn't specify what I should talk about. Considering our mutual interests, I would like to examine with you a perspective of our future agriculture as it looks to an agricultural scientist. And for this purpose, I should like to proceed mainly from the view-point of basic research, and to consider its potential impact on agriculture during the next half century.

I recognize that you are keenly aware of the history of our agriculture, and are familiar with the steps by which this country has advanced to a position of world leadership in farm production. But since history helps us get a proper perspective I would like to examine briefly the major forces responsible for our agricultural progress so far.

The history of farming in this country seems to be divided broadly into three periods. The first -- extending from Colonial times through World War I -- was a period of physical growth by the development of new lands. In general, total farm output during this first 300 years increased only as additional cropland was put under the plow. Acre for acre, crop yields remained about the same.

Fortunately for our country, there were farsighted individuals during this early period who knew that good farmland would one day all be farmed, and that if we were to build a great Nation something had to be done to increase farming efficiency. The Philadelphia Society for Promoting Agriculture was the first organized group to tackle this problem. Its efforts and those of other like-minded groups brought about the establishment, 100 years ago, of the Land Grant Colleges and the U. S. Department of Agriculture.

Research was encouraged, and new farm practices began to emerge. But even 50 years later crop yields on the average remained the same. Many changes in land use occurred that should have improved yields. Vast areas of highly fertile virgin land were plowed up, and worn-out areas were discarded. Millions of acres of potentially productive wet land were drained. Fertilizer and lime use increased to substantial quantities. New, higher yielding crop varieties were introduced and controls were developed for a number of insect pests and crop diseases. Yet with all these improvements yield levels stayed about the same.

There was only one possible conclusion. All the improvements in farming that had been made had barely succeeded in offsetting the decline in soil productivity that was taking place.

Public concern over this situation was mounting by 1908, when President Theodore Roosevelt convened the first Governor's Conference to consider resource problems. Out of this conference emerged the conservation idea.

The second period in our farming history -- covering roughly the years between the two World Wars -- is notable for two developments. The first of these was the application of mechanical power in farming, which gradually released millions of acres from the production of feed for horses and mules. These acres became available for food production. The second important development was the action taken, on a broad front, by the Federal government, by the States, by industry, and by farmers to improve our agriculture. Research was given due recognition.

The third period in our farming history is the one we are in now. Today we can see the fruits of the efforts started in the earlier periods.

In 1939, when World War II broke out in Europe, American farmers produced a 2½ billion-bushel crop of corn on 88 million acres. Last year, they produced a record 47 percent more on 15 million less acres. The story repeats itself with virtually all major crops. The 740 million bushels of wheat produced in 1939 took 52½ million acres. Last year, on about the same acreage, the crop was 1 billion, 460 million bushels -- virtually double that in 1939. Production of oilseed crops has almost tripled since 1939.

It is the same with livestock. In 1958 we had nearly 3½ million fewer dairy cows than in 1939, but each cow produced 7/8ths of a ton more milk during the year. For every two eggs a hen laid in 1939, her decendant is laying about 3 eggs today. Total egg and poultry production is up 108 percent. We have 60 million beef cattle and calves on the same pastures and range lands that in 1939 supported only 30 million head. We had a pig crop of 95 million in 1958 on the same farm plant that produced 87 million in 1939.

All told, we produced 54 percent more farm commodities last year on fewer acres than we had in 1939.

But these facts and figures alone don't tell the whole story. Figures on manpower required to do the job also are significant. In World War I, we produced our farm commodities with 13½ million workers; in World War II, with 10½ million workers; today there are only 7½ million farm workers.

If the agricultural output we achieved in 1957 -- the latest year for which we have complete figures -- had been produced by the methods available to farmers in 1939, it would have cost the Nation about $7\frac{1}{2}$ billion dollars more in land, labor, capital, and other resources than the actual cost in 1957. These $7\frac{1}{2}$ billion dollars were therefore available for other improvements in our living standards.

The story is not all bright, however. From the economic standpoint, as you well know, farmers have not shared equally with the rest of us in the progress our country has made during the past two decades. They benefited greatly from the adoption of technological improvements when the markets were expanding during World War II and the rehabilitation years. Their purchasing power rose rapidly, and they began to pay debts, to buy land, livestock, and equipment, and to make many farm and home improvements. But as the general level of prices rose, it brought rising costs for farm labor, machinery, and production supplies of all kinds. Then, when the special needs of war and rehabilitation had been met, prices received by farmers began falling, and surpluses began piling up. Thus, in recent years, farmers have been caught in a cost-price squeeze. And the burden of farm surpluses has been felt by the entire economy.

Today our most urgent problem is to find new ways of expanding markets for the abundance now produced on our farms.

Research must develop new industrial uses for agricultural commodities. At the same time, it must give farmers new techniques for producing commodities of uniform quality in high volume -- for producing them in ways that are profitable to farmers and at costs that permit competition with other industrial raw materials.

And now let us look to the future.

We're all aware of the present rapid increase in our population and the predicitions that this trend will continue. The Census Bureau estimates that by the year 2010 we may have 370 million people -- more than twice the population we have today.

This means that just to maintain our present diet levels, we will require twice as much food and other farm products as we're consuming today. New knowledge of nutritional requirements, especially for older and younger age groups, is emphasizing the need for more protective foods -- those high in protein, vitamins, and minerals. Meat, milk and eggs, and fruits and vegetables provide these requirements, but they're also the foods with high production and processing costs. To make our people 50 years from now as well fed as they should be, farmers will have to at least double their present crop output and more than double present production of livestock products.

At the same time, the amount of farmland available is not likely to be increased much beyond the acreage farmers are using today. Some new land can be brought into production by various methods. But, as our population increases, considerable present farm land will go into urban and other non-farm uses. Trends also indicate that our farms will continue to increase in size and decrease in numbers, and that additional farm workers will seek part- or full-time employment in towns and cities.

In summary, then, we can expect that tomorrow's farmers -- with only a little more land and considerably less manpower -- will have to produce for a rapidly increasing population, whose needs and desires will influence, more and more, the kinds and qualities of products produced. Despite our present abundance, these demands will not be met unless ways are found to further increase efficiency throughout agriculture.

Farmers will have to do a better job of conserving soils and using available water supplies. They will need higher yielding strains of crops and livestock with specific qualities to meet special market demands -- lean, tender beef, for example . . . milk with more solids and less fat . . . eggs that retain their initial high quality . . . fruits and vegetables more suitable for freezing and canning . . . field crops with qualities especially useful to industry. Farmers must have more economical and effective methods of controlling diseases, insects, weeds, and weather . . . better fertilizer practices, machines, and other production tools. And they must be able to fit these improvements together into economical farm operations that are flexible enough to allow adjustments in response to changes in market demands.

Furthermore, agricultural efficiency no longer stops at the farm gate. It extends into the processing plant, the retail store, and the home -- wherever farm products are ultimately used. It means maintaining the quality of products after they leave the farm. It means efficient and economical methods of handling, processing, and distribution. And it means efficient utilization of all agricultural commodities -- whether as industrial raw materials or as consumer end-products.

All these things contribute to total agricultural efficiency. And the only way that I know they can be achieved is through agricultural research -- pursued vigorously and steadily by both public and private agencies.

In the Department of Agriculture, we have been concerned with this problem for some time. We've been giving a great deal of thought to the kind of research that will help us to make the most progress over the long term.

We have become convinced that our greatest need is for basic research to discover new principles and new methods that will help us to understand fundamental biological processes.

We are fortunate to have seen in our own lifetime how basic research in the physical sciences has given man new power to manage molecules and new insight even into the nucleus of the atom. We are now in the golden era of the physical sciences. The next golden era in science will be in the biological sciences. It will come as we gain understanding of the cell as the unit of life.

The findings of this research promise to rival in importance anything that man has ever done. They will be particularly important to agriculture. If we can better understand and control the mechanisms and functions of living cells, we will have vastly increased ability to breed more productive, higher quality crops and livestock . . . to control or eradicate diseases and insect pests . . . to maintain the quality of farm products during processing and marketing . . . to find new uses for farm-grown raw materials . . . and to improve human nutrition.

Let us examine some of the puzzles we face in our efforts to understand the workings of cells.

Anyone who has grown a plant knows that nutrient elements, such as potassium, pass readily from the soil into the plant. It may surprise some of you to learn that no one knows how this takes place.

The mystery is that, in the soil, nutrient elements occur typically in solutions having low concentrations. Inside the plant, however, the concentration of the same nutrients is typically high. And yet plant nutrients are regularly transferred from the area of low concentration in the soil to the area of high concentration in the plant.

If we can find out why this "up-hill" flow occurs, it will give us new insight into plant growth and undoubtedly will lead us to more efficient methods of fertilizing crops.

Many of you have had the experience of seeing land that has not been plowed for some years suddenly show a full cover of weeds when it was plowed, even though none of the weeds had grown on this land for years. You have probably asked how weed seeds could stay dormant in the soil for so long -- sometimes for as much as 20 years -- and then, following the plowing, suddenly germinate.

We now know that exposure to light in the plowing process, even though only for a few seconds, is responsible for triggering the germination. Likewise, light controls flowering, stem elongation, pigment formation, tuberization, and many other growth processes.

Here again we have the unanswered question of how light regulates these phenomena. As a first step we need to know the chemistry of the active material in the cell that absorbs the light. Knowing that, we can take another step.

When we fully understand what light does in seed germination, we may find a way to make all weed seeds in the soil germinate at once, in the dark, and then quickly get rid of the weeds.

If we could unravel some of the chemical processes occurring within living cells, we would be much nearer to an understanding of the fundamental nature of life .

How do viruses reproduce themselves, when other large protein molecules not containing nucleic acid cannot do so? What is the nature of the chemical or physical changes which result in virus mutations? If we had the answers to these questions, we might be able to produce mild strains of many viruses capable of immunizing plants and animals against diseases caused by more virulent strains. Or we might develop chemical methods for destroying the viruses.

A part of this riddle is that all proteins are composed of the same amino acids combined in various ways and proportions. Yet one protein turns out to be inert, another with nucleic acid is a virus, and still another is an enzyme. And enzymes are the controlling catalysts in metabolic processes.

There are many different enzymes -- at least one for each process. Yet there is an underlying unity in the molecules that nature uses for its processes. Similar enzyme molecules catalyse similar reactions both in one-celled organisms and in higher animals. This gives us hope that in our studies of plants and animals and microorganisms we will one day be able to fit the pieces of our jig-saw puzzle together into an understanding of the nature and behavior of enzymes and viruses and, in fact, of all proteins.

This knowledge will help us to understand metabolic processes in cells. It could well turn out that major errors in cell metabolism may be involved in cancer, and that the accumulative effect of minor metabolic errors or imbalances may contribute to the aging process. If we can learn more about cell metabolism and the cause or control of errors in this basic life process, it could benefit not only agriculture but all mankind.

A question that has long troubled biologists is what makes one cell reproduce itself and eventually become a muscle, while other cells develop through a similar process into nerves, fat, cartilage, or bone? It seems likely that genes and cytoplasmic particles play a major role in both development and differentiation. This leads to the question of what is the nature and structure of the fundamental unit of heredity, and how does it produce its effect?

Recent evidence indicates that the gene may not be the fundamental unit of heredity, terms of composition, but may consist of chemical sub-units. An understanding of the chemical organization of the fundamental units, how they reproduce themselves, and how they produce their effects in the organism would provide valuable new methods of genetic control in plant and animal populations.

If we can understand the chemistry of genes, we may learn how to modify them by chemical treatment. From this it follows that metabolic processes would become subject to modification.

The implications of such mastery over biological behavior are tremendous. If specific desirable changes could be made, the rate and amount of genetic improvement in animal and plant populations would far exceed anything now possible.

I have only touched on a few of the questions research must answer if our agriculture is to meet the demands that will be placed upon it 50 years from now and in the longer future. There are many others -- dealing with every phase of agriculture. And involved in all of them are the problems farmers will face in adjusting to the changes that will come because of technological developments -- both on and off the farm. This means that we must do much more research also in the economics of production, utilization, and marketing -- so that we can give farmers the information they need to make the right decisions in adjusting their operations in light of market demands.

The success of research in helping agriculture meet the needs of the year 2010 -- or of the time between now and then -- depends on many things. But certainly the most important is the support given to basic research. I am exceedingly pleased that both in the Land Grant Colleges and in the Department of Agriculture great strides have been made in recent years to strengthen our basic work. It now accounts for more than 20 percent of our total effort. But more still needs to be done.

I should like to suggest that the Philadelphia Society for Promoting Agriculture, which has such a long and distinguished record of supporting agricultural science in the past, might become the champion of basic research, the key to a greater agriculture for the future.

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